Summary of Biophysical Data for Climate Change Adaptation for the Hunter LLS

Key Points

- Numerous models and tools are available to spatially identify projected changes to natural resources in response to climate change (usually no cost to download). They are useful for decision support in land use planning under future climate change, although often require GIS skills and downscaling for regional applications
- When models predicting the impacts of climate change on ecosystems are not available, information on the distribution of ecosystem, species and land use (usually no cost to download) can be combined with general ecological principles to increase ecosystem resilience and facilitate climate change adaptation. This information is available in a range of formats, e.g. maps, Excel spread sheets, reports and tables, and often as user-friendly interactive online downloads.
- The information provided here can be used as a starting platform for climate change adaptation, but because this information is constantly evolving, this list is not exhaustive

Introduction

Numerous types of data are required to inform climate change adaptation for natural resource management. The baseline datasets required detail the existing distribution of species and ecosystems, these will respond differently (i.e. vary in their sensitivity) to the changes in climate. Information on sensitivity can be combined with information on the exposure of natural resources to changes in climate to highlight the potential impact of climate change on the distribution and function of natural resources. The capacity of these ecosystems to adapt will be based on, for example, their ecological characteristics or land use. By understanding the potential impact of climate change on natural resources and their capacity to adapt to these impacts, we can plan for climate change adaptation. Here, we summarise the information available to assist NRM regional bodies in climate adaptation planning.

We separate the information into that available at the scale of the Hunter Local Land Services (LLS) (Table 1) and at the national scale (Table 2). We identify the type of information available and its ease of use for NRM planning (e.g. modelling tools, data, maps and general frameworks). We also include examples of climate adaptation-related scientific literature (Table 3).

Hunter LLS

There are numerous baseline data sources that can inform climate adaptation in this region, including:

- The data on native vegetation (PVP Developer) in their district, wetland health and a BioMetric tool that assesses terrestrial biodiversity at the scale of the patch, paddock or property.
- NARCLiM (NSW/ACT) Regional Climate Modelling is under development. It is designed to give the community easy access to both raw climate modelled data and information that combines the model projections into climate statistics by providing an ensemble of dynamically downscaled regional climate projections.
- Information on the impacts of climate on natural resources would ideally be linked to information on the impacts of the changing land-use (e.g. available on the Land Use Options Simulator (LUOS) and the Biodiversity Forecasting Toolkit)
- Phoenix-Rapidfire Simulation model predicts flame height, fire intensity and ember density based on a range of input data relating to topography, fuels and weather.
- For the Hunter LLS, additional data is available from Hunter & Central Coast Regional Environmental Management Strategy (HCCREMS).

Table 1 List of tools/models, maps and general information relating to biophysical climate change adaptation

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Tool/Model	**Maps/ Information**	**Use characteristics**	**Description**	**Link/Reference**
NARCLiM (NSW / ACT Regional Climate Modelling)	Future climate data and information		Under development: Regional Climate Modelling. Robust climate change projections at a scale relevant for use in local-scale decision-making.	http://www.ccrc.unsw.edu.au/NARCliM/description.html
Planning & Environment tool	Maps and spatial data		Free online: Data for planning, e.g. coastal and littoral protected areas, agriculture, land zoning.	http://www.planning.nsw.gov.au/enus/planningyourregion/spatialdata.aspx
IRVA (Integrated Regional Vulnerability)	Adaptation information and workshops		Develops a shared understanding among stakeholders of the likely vulnerability to climate change.	http://www.environment.nsw.gov.au/climatechange/irvadescription.htm
PVP (Property Vegetation Plan)	Separate modules for salinity, water quality, biodiversity (including threatened species), land and soil capability and invasive native species		Free online: Provides landholders, Landcare groups, local CMA staff and the public with access to the best available science and information on native vegetation in their district.	http://www.environment.nsw.gov.au/resources/vegetation/nvinfosheet8.pdf Data can be accessed via the LLSs.
BioMetric Assessment tool	Operation manual and datasheets		Free online: Assesses impacts on terrestrial biodiversity of clearing/thinning remnant native vegetation and protected regrowth under the NSW Native Vegetation Act 2003. *BioMetric* is used in GIS.	http://www.environment.nsw.gov.au/projects/BiometricTool.htm
LUOS (Land Use Options Simulator)	Maps and spatial data		Free online: Relevant to salinity management, including: Native vegetation, soil, land use, recharge and run-off, potential discharge areas, salt outbreak areas, and groundwater flow systems.	http://www.environment.nsw.gov.au/salinity/science/mapping.htm
HCCREMS (Hunter & Central Coast Regional Environmental Management Strategy)	Maps and spatial data		Available for purchase: towns, roads, rivers, national parks, heritage areas, tourism sites, fauna habitat, and topography.	http://www.hccrems.com.au/RESOURCES/Maps.aspx

Table 2 List of tools/models, maps and general information relating to biophysical climate change adaptation. Data preparation/GIS skills required (red), optional (yellow), not required (green). Downscaling required (red), optional (yellow), not required (green). Accessibility/ Ease of use (red = low, yellow = medium, green = high).

National scale (all of cluster)				
Tool/Model	**Maps/ Information**	**Use characteristics**	**Description**	**Link/Reference**
MAXENT (Species distribution modelling tool)			Free software download: Integrates with ArcGIS to produce probability maps and statistics -current and future climate scenarios.	http://www.cs.princeton.edu/~schapire/maxent/
CLiMAS (Suitability Species distribution modelling tool)	Maps and spatial data		Free download: Can examine current climate space available to Australian vertebrate species and how models project suitable space to change in the future.	http://tdh-tools-2.hpc.jcu.edu.au/climas/SpeciesSuitability.php
AVH (Australia's Virtual Herbarium)	Maps and point data (excel format)		Free download: Distributions of Australian native flora species, current and historical.	http://avh.chah.org.au/
ALA (Atlas of Living Australia)	Maps & point data		Free online: Biodiversity data covering the lives/nature of Australian species.	http://spatial.ala.org.au/
Erosivity (run-off calculator)			A step-by-step approach for using the SCS (USDA Soil Conservation Service) runoff equation.	ftp://ftp.wcc.nrcs.usda.gov/wntsc/H&H/training/SCS-runoff-equation.pdf
PCMDI (Program For Climate Model Diagnosis & Inter-comparison)	Reports (PDF format)		Free access: Program for climate model diagnosis and intercomparison. Provides an evaluation of climate models.	http://www-pcmdi.llnl.gov/ipcc/about_ipcc.php
Terra Nova (The Australian Climate Change Adaptation Information Hub)	Data repository		Under development. Aims to build a software system that acts as a central information hub for researchers in the Climate Change Adaptation research domain. Decision support information.	http://ccaih.org.au/ Brendan Mackey (Griffith Uni)
OzClim (Climate Change Scenario Generator)	Maps and spatial data		Free download: CSIRO climate projections for 2020-2100 for ocean temp & salinity, temp, rainfall, wind speed, evapotranspiration & humidity.	http://www.csiro.au/ozclim/home.do
OzCoasts (Coastal information)	Maps		Free online: Shows low-lying areas potentially vulnerable to flooding from combined sea level rise and very high tide for three sea level rise scenarios at 2100.	http://www.ozcoasts.gov.au/climate/Map_main.jsp
ASRIS (Australian Soil Resource Information System)	Maps and spatial data		Free online: Soil landscapes, usually comprising a number of soil types.	http://www.asris.csiro.au/themes/Atlas.html
ABARES (Australian Bureau of Agricultural and Resource Economics & Sciences)	Tables & graphs		Free online: Forestry models of ground cover, plant growth, temperature, rainfall etc. for current climate.	http://www.daff.gov.au/abares/data
DLC (Dynamic Land Cover)	Maps and GIS data (TIFF format)		Free online: Satellite imagery. Baseline for identifying and reporting on change and t-rends in vegetation cover and extent.	http://www.ga.gov.au/earth-observation/landcover.html
DAFF (Department of Agriculture Fisheries and Forestry)	Interactive maps		Free online: Soil moisture, rainfall, pasture growth, temperature, ground cover, ecosystem services.	http://data.daff.gov.au/monitor/explore.html
NVIS (National Vegetation Information Systems)	Maps and spatial data		Free online: Native vegetation cover. Variety and distribution of native vegetation.	http://www.environment.gov.au/topics/science-and-research/databases-and-maps/national-vegetation-information-system

Tool/Model	Maps/ Information	Accessibility/ Ease of use	Description	Link/Reference
DAFF Australian Dryland Salinity Assessment	Maps and spatial data		Free online: Dryland salinity risk and hazard mapping for 2000, 2020 and 2050. Shows the broad distribution of areas considered as having either a high salinity risk or a high salinity hazard.	http://data.gov.au/dataset/australian-dryland-salinity-assessment-spatial-data-12500000-nlwra-2001
GRASSGRO Pasture production model	Weather information		Available to purchase: Grazing systems research for farmers and advisors. Daily weather data drive models of interacting processes of pasture growth and animal production.	http://www.grazplan.csiro.au/files/brchr_grassgro.pdf and horizonag@hzn.com.au www.hzn.com.au/grassgro.htm
CIRCUITSCAPE Connectivity/Corridor model			Free online: Data integrates with ArcGIS. Algorithms predict patterns of movement, gene flow, and genetic differentiation among plant and animal populations.	http://www.circuitscape.org/home
VAST Vegetation Assets, States and Transitions	Charts, maps, tables		Free online: A framework to classify vegetation according to its degree of anthropogenic modification from a natural state.	http://data.daff.gov.au/VAST/
BIODIVERSE Spatial analysis of diversity tool			Free online: Uses indices based on taxonomic, phylogenetic and matrix-based (e.g. genetic distance) relationships, as well as related environmental and temporal variations.	http://code.google.com/p/biodiverse/wiki/KeyConcepts
Protected area matters tool	Maps and spatial data		Free online: Protected areas, marine protected areas. Aust. Gov.	http://www.environment.gov.au/webgis-framework/apps/pmst/pmst.jsf
SLAMM (Sea Level Rise Affecting Marshes Model)	Simulation model		Simulates the dominant processes involved in wetland conversions and shoreline modifications during long-term sea level rise.	http://www.warrenpinnacle.com/prof/SLAMM/
DEM (Digital Elevation Model) 9-second /250 metres			Free online: Geoscience Australia. GIS data (shapefile) grid of ground- level elevation points covering the whole of Australia.	https://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=66006
Rainfall to pasture growth tool	Reports		Free online: Provides information and outlook for southern Qld and NSW, by weather station: rainfall, soil moisture, pasture growth.	http://www.mla.com.au/News-and-resources/Tools-and-calculators/Rainfall-to-pasture-growth-outlook-tool
MCAS-S (Multi-Criteria Analysis Shell Software) tool	Maps and spatial data for MCAS-S tool.		Free online: Spatial decision support: Biophysical (vegetation, soil, terrain, water, and climate and economic (land use, agricultural commodity, income, land value, rate of return).	http://www.daff.gov.au/abares/data/mcass
SDSM (Downscaling model)			Free online: For assessing local climate change impacts using a robust statistical downscaling technique.	http://copublic.lboro.ac.uk/cocwd/SDSM/ C.W.Dawson@sdsm.org.uk
CFI (Carbon Farming Initiative) Reforestation Modelling Tool			Free online: Estimates Carbon Sequestration using inputs, e.g. Coordinates, area, vegetation. Assists developers with participating in the CFI.	http://ncat.climatechange.gov.au/cfirefor/
APSIM (Agricultural Production Systems Simulation) tool			Free online: A suite of modules which enable the simulation of systems that cover a range of plant, animal, soil, climate and management interactions.	http://www.apsim.info/
MARXAN Conservation Planning tool			Free online: Provides decision support for the design of reserve systems.	http://www.uq.edu.au/marxan/index.html?page=77654&p=1.1.4.1

Tool/Model	Maps/ Information	Accessibility/ Ease of use	Description	Link/Reference
Climate Change in Australia	Maps and spatial data		Under development. Free online: State and national-scale projections of the average climate around 2030, 2050 and 2070 for temperature, rainfall & other climate variables.	http://www.climatechangeinaustralia.com.au/
Protected area matters tool	Maps and spatial data		Free online: Protected areas, marine protected areas. Aust. Gov.	http://www.environment.gov.au/webgis-framework/apps/pmst/pmst.jsf
USLE (Soil Loss Equation) tool			Free online: Calculates hill slope erosion severity over space and time and potential post-fire soil erosion risk. *Need R-value calculated for Australian region*.	http://www.omafra.gov.on.ca/english/engineer/facts/12-051.htm Xihua Yang, Greg Chapman (NSW OEH)
NCCARF (National Climate Change Adaptation Research Facility)	Data portal		Free online: Access to research publications and newsletters on a wide range of climate change issues.	http://www.nccarf.edu.au/
MCAS-S (Multi-Criteria Analysis Shell Software) tool (DAFF/ABARES)			Free online: GIS data. Assists in participatory processes and workshop situations where a clear understanding of varying approaches to spatial data management and information arrangement is necessary.	http://www.daff.gov.au/abares/data/mcass/tool
ZONATION Conservation prioritisation tool			Free software online: Produces a hierarchical prioritization of the landscape based on the occurrence levels of features in sites (cells). Iteratively removes least valuable remaining cell, accounts for connectivity and complementarity.	http://www.helsinki.fi/bioscience/consplan/software/Zonation/onlines.html
CSIRO	Data portal		Free online: GIS data (e.g. Topographic wetness index). CSIRO's research and data collections: agriculture, environmental sciences, and earth sciences.	https://data.csiro.au/dap/landingpage?pid=csiro:5588&v=1&d=true
TERN (Terrestrial Ecosystem Network)	Data portal		Free online: Different data sets (including soils, terrain, water, satellite images, and survey data and species observation records) for the same geographic area.	http://www.tern.org.au/TERN-Data-Discovery-Portal-pg17727.html
ACEAS (The Australian Centre for Ecological Analysis and Synthesis)	Data portal		Free online: Virtual facility within TERN for disciplinary and inter-disciplinary integration, synthesis and modelling of ecosystem data to aid in development of evidence-based environmental management strategies and policy.	http://www.aceas.org.au/
MATCHES (Eastern Seaboard Climate Hazard Tool)	Information: East Coast Lows		Under development: Draws on the BoM's rainfall and wind datasets and Manly Hydraulics Laboratory's wave height and water-level datasets. Will provide users across a range of sectors with the ability to assess their own climatic risk associated with East Coast Lows.	http://www.coastalconference.com/2011/papers2011/Aaron%20Coutts-Smith%20Full%20Paper.pdf

Table 3 Examples of relevant scientific publications

Description	Reference/Link
SLT (Spatial Links Tool). Evaluating the contribution and potential contribution of connecting paths to landscape connectivity link value maps can be used to delineate habitat corridors. **(Journal publication)**	Drielsma *et al*. (2007) The spatial links tool: Automated mapping of habitat linkages in variegated landscapes, *Ecological Modelling* **200**, (3–4), pp. 403–411. http://65.54.113.26/Publication/40857810/the-spatial-links-tool-automated-mapping-of-habitat-linkages-in-variegated-landscapes
Identifies centres of endemism & potential past refugia for subtropical rainforest plants via historical climate fluctuations. **(Journal publication)**	Weber *et al*. (2014) Patterns of rain forest plant endemism in subtropical Australia relate to stable mesic refugia and species dispersal limitations. *Journal of Biogeography*. **41**, pp. 222–238. http://onlinelibrary.wiley.com.ezproxy.library.uq.edu.au/doi/10.1111/jbi.12219/abstract
Species distribution models. **(Journal publication)**	Adams-Hosking *et al*. (2012) Modelling changes in the distribution of the critical food resources of a specialist folivore in response to climate change *Diversity & Distributions* **18**, pp. 847–860. http://onlinelibrary.wiley.com.ezproxy.library.uq.edu.au/doi/10.1111/j.1472-4642.2012.00881.x/abstract
HYDRUS /CATSALT salinity model. **(Journal publication)**	Tuteja *et al*. (2003) Predicting the effects of landuse change on water and salt balance – A case study of a catchment affected by dryland salinity in NSW, Australia. *Journal of Hydrology.* 283, (1-4) 10 pp. 67-90. http://www.sciencedirect.com.ezproxy.library.uq.edu.au/science/article/pii/S0022169403002361
Mapping of endemic flora throughout continental Australia and Tasmania to visualize the pattern of species richness. **(Journal publication)**	Crisp *et al*. (2002) Endemism in the Australian flora, *Journal of Biogeography*, **28**, (2) pp. 183–198. http://onlinelibrary.wiley.com/doi/10.1046/j.1365-2699.2001.00524.x/abstract
Accumulation with discrete annual litter falls (for incorporation into Forest Fire Forest Fire Danger Meter fire behaviour model (McArthur, 1967). **(Journal publication)**	Olson, (1963) Energy storage and the balance of producers and decomposers in ecological systems. *Ecology*, **44** pp. 322–331. http://www.jstor.org.ezproxy.library.uq.edu.au/stable/info/1932179#abstract
The MARS approach to regression modeling effectively uncovers important data patterns and relationships that are difficult, if not impossible, for other regression methods to reveal. **(Journal publication)**	Hermoso *et al*. (2013) Data Acquisition for Conservation Assessments: Is the Effort Worth It? *PLoS ONE* **8**(3): e59662. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3608668/?report=classic
Mangrove forests. **(Journal publication)**	Bell & Lovelock (2013) Insuring Mangrove Forests for Their Role in Mitigating Coastal Erosion and Storm –Surge. *Wetlands*, **33**, pp.279–289. http://link.springer.com.ezproxy.library.uq.edu.au/article/1.1007/s13157-013-0382-4/fulltext.html
Carbon Farming. **(Journal publication)**	Polglase *et al*. (2013). Potential for forest carbon plantings to offset greenhouse emissions in Australia: Economics and constraints to implementation. *Climatic Change*, **121**, 161-175. http://link.springer.com.ezproxy.library.uq.edu.au/article/10.1007/s10584-013-0882-5/fulltext.html
Spatially explicit distribution model for seagrass vs. non-seagrass habitats, simulation of change in sea level and changes in distribution of seagrass habitat due to SLR. **(Journal publication)**	Saunders *et al*. (2013). Coastal retreat and improved water quality mitigate losses of seagrass from sea level rise. *Global Change Biology* **19**, (8) pp. 2569–2583. http://onlinelibrary.wiley.com.ezproxy.library.uq.edu.au/doi/10.1111/gcb.12218/abstract
Tested whether the soil surface elevation of mangroves and salt marshes in Moreton Bay is keeping up with local rates of sea level rise (2.358 mm y-1) and whether accretion on the soil surface was the most important process for keeping up with SLR. **(Journal publication)**	Lovelock *et al*. (2011) The Role of Surface and Subsurface Processes in Keeping Pace with Sea Level Rise in Intertidal Wetlands of Moreton Bay, Queensland, Australia, *Ecosystems*, **14**, 745–757. http://link.springer.com.ezproxy.library.uq.edu.au/article/10.1007/s10021-011-9443-9/fulltext.html

Description	Reference/Link
Adaptation of SLAMM model of wetland transitions under sea-level rise and outcomes for threatened species in Moreton Bay. **(Journal publication)**	Traill *et al*. (2011) Managing for change: wetland transitions under sea-level rise and outcomes for threatened species *Diversity & Distributions* **17**, 1225–1233. http://onlinelibrary.wiley.com.ezproxy.library.uq.edu.au/doi/10.1111/j.1472-4642.2011.00807.x/abstract
Phoenix- Rapidfire Simulation model Predicts flame height, fire intensity and ember density based on a range of input data relating to topography, fuels and weather. Fire propagation is simulated using Huygens's algorithm. Assessment of the potential effect of revegetation on fire regimes and fire risk within agricultural landscapes of the Hawkesbury-Nepean catchment area. Used in NSW. **(Journal publication)**	Tolhurst *et al.* (2008) Phoenix: development and application of a bushfire risk management tool. *Australian Journal of Emergency Management*, **23**, 47-54. http://search.informit.com.au.ezproxy.library.uq.edu.au/documentSummary;res=IELHSS;dn=609496843850011 http://www.bushfirecrc.com/sites/default/files/managed/resource/fire_note_109_high_res.pdf
Sea Level Affecting Marshes model (SLAMM). Uses digital elevation data and other information to simulate potential impacts of long-term sea level rise on wetlands and shorelines. **(Journal publication)**	Mills *et al*. in review
Terrestrial biodiversity. **(Journal publication)**	Gibbons *et al*. (2009) An operational method to assess impacts of land clearing on terrestrial biodiversity. *Ecological Indicators*. **9** (1), 26-40. http://www.sciencedirect.com.ezproxy.library.uq.edu.au/science/article/pii/S1470160X08000058
Overview of modelling techniques & decision support systems: application for managing salinity in Australia. **(Open access publication)**	http://www.environment.nsw.gov.au/resources/salinity/pursllittleboyetal.pdf
Ensis-CSIRO, Canberra. DEFFM - Dry Eucalypt Forest Fire Model. Developed under a broader range of weather and fuel conditions. **(Open access publication)**	http://bushfire.boab.info/sites/default/files/managed/resource/jim-gould-lachie-mccaw-phil-cheney.pdf http://www.csiro.au/Outcomes/Safeguarding-Australia/VestaTechReport.aspx Available to purchase $29.95
Climate Change Refugia for Terrestrial Biodiversity **(Open access publication)**	Reside *et al*. (2013) http://www.nccarf.edu.au/publications/climate-change-refugia-terrestrial-biodiversity
Protecting and restoring habitat to help Australia's threatened species adapt to climate change Final Report. **(Open access publication)**	Maggini *et al*. (2013) http://www.nccarf.edu.au/publications/habitat-australias-species-adapt-climate
PERFECT Water balance model. **(Conference publication)**	Owens, J., Tolmie, P., Foley, J. and Silburn, M. (2003). Understanding deep drainage from clay soils in the Queensland Murray-Darling Basin using lysimetry, chloride balance and modelling. Proceedings 9th Productive Use and Rehabilitation of Saline Lands Conference. September 29 – October 2, Yeppoon.
Characterising climate change and/or shoreline erosion risks and associated impacts on Sunshine Coast, SEQ. **(Conference publication)**	Barnes, *et al*. (2011) Managing the Sunshine Coast shoreline erosion threat. 20th Australasian Coastal and Ocean Engineering Conference 2011 and the 13th Australasian Port and Harbour Conference 2011. - Coasts and Ports 2011: Diverse and Developing: Proceedings pp. 24-29.
GRASP Pasture model. **(Book)**	Rickert *et al*. (2000). Modelling pasture and animal production. In: 'Field and Laboratory Methods for Grassland and animal Production Research'. (eds. L 't Mannetje and R.M. Jones). pp. 29-66.
FFDM-Fire Forest Fire Danger Meter Fire behaviour in eucalypt forests. Leaflet 107, Forestry and Timber Bureau, Canberra, ACT. **(Book)**	http://trove.nla.gov.au/work/21914760?selectedversion=NBD560676 McArthur, (1967) Available to borrow from library.
Gould *et al*. (2008) Field Guide: Fire in Dry Eucalypt Forest Fuel Assessment and Fire Behaviour Prediction in Dry Eucalypt Forest. **(Book)**	http://www.publish.csiro.au/pid/5991.htm Available to purchase $24.95
McArthur, A. G. (1967) Fire behaviour in eucalypt forests, Forestry and Timber Bureau, Canberra **(Book)**	http://trove.nla.gov.au/work/21914760?selectedversion=NBD560676
Adapting Agriculture to Climate Change Preparing Australian Agriculture, Forestry and Fisheries for the Future, eds. Chris Stokes & Mark Howden, (2010). **(Book)**	CSIRO Publishing, Collingwood, Australia.

Further Information

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